Copy for the Elected Office (EO/US) PCT/US97/23992

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF THE RECORDING OF A CHANGE

(PCT Rule 92bis.1 and Administrative Instructions, Section 422)

To:

TRIPOLI, Joseph, S.
Thomson Multimedia Licensing
Incorporated
P.O. Box 5312
Princeton, NJ 08540
ÉTATS-UNIS D'AMÉRIQUE

Date of mailing (day/month/year) 29 July 1999 (29.07.99)	
Applicant's or agent's file reference RCA 88692	**IMPORTANT NOTIFICATION**
International application No. PCT/US97/23992	**International filing date** (day/month/year) 23 December 1997 (23.12.97)

1. The following indications appeared on record concerning:

☐ the applicant ☐ the inventor ☒ the agent ☐ the common representative

Name and Address	State of Nationality	State of Residence
TRIPOLI, Joseph, S. GE & RCA Licensing Management Operation, Inc. P.O. Box 5312 Princeton, NJ 08543 United States of America		
	Telephone No. 1 609 734 9754	
	Facsimile No. 1 609 734 9700	
	Teleprinter No.	

2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning:

☐ the person ☐ the name ☒ the address ☐ the nationality ☐ the residence

Name and Address	State of Nationality	State of Residence
TRIPOLI, Joseph, S. Thomson Multimedia Licensing Incorporated P.O. Box 5312 Princeton, NJ 08540 United States of America		
	Telephone No. 1 609 734 9497	
	Facsimile No. 1 609 734 9700	
	Teleprinter No.	

3. Further observations, if necessary:

4. A copy of this notification has been sent to:

☒ the receiving Office
☐ the International Searching Authority
☒ the International Preliminary Examining Authority
☐ the designated Offices concerned
☒ the elected Offices concerned
☐ other:

The International Bureau of WIPO **34, chemin des Colombettes** **1211 Geneva 20, Switzerland** Facsimile No.: (41-22) 740.14.35	Authorized officer Catherine Massetti Telephone No.: (41-22) 338.83.38

Form PCT/IB/306 (March 1994) 002761242

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

United States Patent and Trademark Office
(Box PCT)
Crystal Plaza 2
Washington, DC 20231
ÉTATS-UNIS D'AMÉRIQUE

in its capacity as elected Office

Date of mailing (day/month/year) 29 July 1999 (29.07.99)	
International application No. PCT/US97/23992	**Applicant's or agent's file reference** RCA 88692
International filing date (day/month/year) 23 December 1997 (23.12.97)	**Priority date** (day/month/year)
Applicant YU, Haoping et al	

1. The designated Office is hereby notified of its election made:

   [X] in the demand filed with the International Preliminary Examining Authority on:

   08 July 1999 (08.07.99)

   [ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was
   [ ] was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO **34, chemin des Colombettes** **1211 Geneva 20, Switzerland** Facsimile No.: (41-22) 740.14.35	Authorized officer Catherine Massetti Telephone No.: (41-22) 338.83.38

EXPRESS MAIL EL 498033911US

PATENT COOPERATION TREATY

From the INTERNATIONAL SEARCHING AUTHORITY

To:

GE & RCA Licensing Management
Operation, Inc.
Attn. Tripoli, Joseph S.
P.O. Box 5312
Princeton, New Jersey 08543
UNITED STATES OF AMERICA

PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL SEARCH REPORT OR THE DECLARATION

(PCT Rule 44.1)

RECEIVED APR 13 1998

	Date of mailing (day/month/year) 06/04/1998
Applicant's or agent's file reference RCA 88692	**FOR FURTHER ACTION** See paragraphs 1 and 4 below
International application No. PCT/US 97/23992	International filing date (day/month/year) 23/12/1997
Applicant THOMSON CONSUMER ELECTRONICS, INC. et al.	

1. [X] The applicant is hereby notified that the International Search Report has been established and is transmitted herewith.

Filing of amendments and statement under Article 19
The applicant is entitled, if he so wishes, to amend the claims of the International Application (see Rule 46):

When? The time limit for filing such amendments is normally 2 months from the date of transmittal of the International Search Report; however, for more details, see the notes on the accompanying sheet.

Where? Directly to the International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland
Fascimile No.: (41-22) 740.14.35

For more detailed instructions, see the notes on the accompanying sheet.

2. [ ] The applicant is hereby notified that no International Search Report will be established and that the declaration under Article 17(2)(a) to that effect is transmitted herewith.

3. [ ] **With regard to the protest** against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:

[ ] the protest together with the decision thereon has been transmitted to the International Bureau together with the applicants's request to forward the texts of both the protest and the decision thereon to the designated Offices.

[ ] no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.

4. **Further action(s):** The applicant is reminded of the following:

Shortly after **18 months** from the priority date, the international application will be published by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau as provided in Rules 90*bis*.1 and 90*bis*.3, respectively, before the completion of the technical preparations for international publication.

Within **19 months** from the priority date, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase until 30 months from the priority date (in some Offices even later).

Within **20 months** from the priority date, the applicant must perform the prescribed acts for entry into the national phase before all designated Offices which have not been elected in the demand or in a later election within 19 months from the priority date or could not be elected because they are not bound by Chapter II.

Name and mailing address of the International Searching Authority	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Patricia Klingens-Herklots

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference RCA 88692	**FOR FURTHER ACTION** see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
International application No. PCT/US 97/ 23992	International filing date *(day/month/year)* 23/12/1997	(Earliest) Priority Date *(day/month/year)*
Applicant THOMSON CONSUMER ELECTRONICS, INC. et al.		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 3 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. [ ] **Certain claims were found unsearchable** (see Box I).

2. [ ] **Unity of invention is lacking** (see Box II).

3. [ ] The international application contains disclosure of a **nucleotide and/or amino acid sequence listing** and the international search was carried out on the basis of the sequence listing
   - [ ] filed with the international application.
   - [ ] furnished by the applicant separately from the international application,
     - [ ] but not accompanied by a statement to the effect that it did not include matter going beyond the disclosure in the international application as filed.
   - [ ] Transcribed by this Authority

4. With regard to the **title**,
   - [ ] the text is approved as submitted by the applicant
   - [X] the text has been established by this Authority to read as follows:

   LOW NOISE ENCODING AND DECODING APPARATUS AND METHOD

5. With regard to the **abstract**,
   - [X] the text is approved as submitted by the applicant
   - [ ] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this International Search Report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is:

   Figure No. 2
   - [X] as suggested by the applicant.
   - [ ] because the applicant failed to suggest a figure.
   - [ ] because this figure better characterizes the invention.
   - [ ] None of the figures.

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 97/23992

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04N7/26

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 253 059 A (ANSARI RASHID ET AL) 12 October 1993	16-18
A	see column 3, line 25 - column 4, line 33; figure 1	1,13
X	US 5 049 993 A (LEGALL DIDIER J ET AL) 17 September 1991	16
A	see column 6, line 58 - column 7, line 8; figures 1,6	1,13
A	US 5 530 484 A (BHATT BHAVESH B ET AL) 25 June 1996 see column 2, line 55 - column 5, line 65	19
A	EP 0 595 323 A (SONY CORP) 4 May 1994 see column 6, line 37 - column 12, line 22	1,13
	-/--	

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

1

Date of the actual completion of the international search	Date of mailing of the international search report
26 March 1998	06/04/1998

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Beaudoin, O

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 97/23992

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate. of the relevant passages	Relevant to claim No.
A	WO 95 15659 A (COMPRESSION LABS INC) 8 June 1995 see page 25, line 29 - page 29, line 14	1,13
A	EP 0 708 564 A (AT & T CORP) 24 April 1996 see page 3, line 48 - page 4, line 27; figure 2 see page 8, line 44 - page 9, line 30; figure 5	1,13
A	EP 0 685 968 A (VICTOR COMPANY OF JAPAN) 6 December 1995 see column 17, line 49 - column 19, line 8	1,13
A	WO 96 27981 A (PHILIPS ELECTRONICS NV ;PHILIPS NORDEN AB (SE)) 12 September 1996 see page 2, line 13 - page 3, line 3; figure 1 see page 4, line 25 - page 5, line 12	1,13
A	WO 97 39577 A (SNELL & WILCOX LTD ;KNEE MICHAEL JAMES (GB); SOMERVILLE STUART (GB) 23 October 1997 see page 7, line 14 - line 27	1,13
A	EP 0 498 625 A (GRASS VALLEY GROUP) 12 August 1992 see column 2, line 56 - column 4, line 56	1,13

1

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US 97/23992

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5253059 A	12-10-93	NONE	
US 5049993 A	17-09-91	NONE	
US 5530484 A	25-06-96	AU 5233396 A	28-11-96
		CN 1140950 A	22-01-97
		EP 0743791 A	20-11-96
		JP 8322022 A	03-12-96
EP 0595323 A	04-05-94	JP 6153069 A	31-05-94
		AU 672238 B	26-09-96
		AU 5032293 A	12-05-94
		EP 0809399 A	26-11-97
		EP 0809400 A	26-11-97
		US 5485280 A	16-01-96
		US 5594552 A	14-01-97
		US 5510902 A	23-04-96
WO 9515659 A	08-06-95	AU 1210495 A	19-06-95
EP 0708564 A	24-04-96	CA 2157309 A	22-04-96
		JP 8214305 A	20-08-96
EP 0685968 A	06-12-95	JP 7327164 A	12-12-95
		US 5517248 A	14-05-96
WO 9627981 A	12-09-96	EP 0759251 A	26-02-97
		JP 9512696 T	16-12-97
WO 9739577 A	23-10-97	AU 2518497 A	07-11-97
EP 0498625 A	12-08-92	DE 69206833 D	01-02-96
		DE 69206833 T	29-08-96
		JP 5145845 A	11-06-93
		US 5289305 A	22-02-94

EXPRESS MAIL EL498033911US

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To: TRIPOLI, Joseph. S. GE & RCA Licensing Management Opera P.O. Box 5312 Princeton, NJ 08543 ETATS-UNIS D'AMERIQUE	MAY 05 2000 **PCT** NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL PRELIMINARY EXAMINATION REPORT (PCT Rule 71.1)
	Date of mailing *(day/month/year)* 10.02.00
Applicant's or agent's file reference RCA 88692	**IMPORTANT NOTIFICATION**

International application No.	International filing date *(day/month/year)*	Priority data *(day/month/year)*
PCT/US97/23992	23/12/1997	23/12/1997

Applicant
THOMSON CONSUMER ELECTRONICS, INC. et al.

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.

2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.

3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

4. **REMINDER**

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

Name and mailing address of the IPEA/	Authorized officer
European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Stannartz, B Tel.+49 89 2399-8242

Form PCT/IPEA/416 (July 1992)

BS22339. 07.02.2000

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference RCA 88692	**FOR FURTHER ACTION**	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
International application No. PCT/US97/23992	International filing date *(day/month/year)* 23/12/1997	Priority date *(day/month/year)* 23/12/1997
International Patent Classification (IPC) or national classification and IPC H04N7/26		
Applicant THOMSON CONSUMER ELECTRONICS, INC. et al.		

1. This International preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 4 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 7 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☒ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations suporting such statement
   - VI ☐ Certain documents cited
   - VII ☒ Certain defects in the international application
   - VIII ☐ Certain observations on the international application

Date of submission of the demand 08/07/1999	Date of completion of this report 10.02.00
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Glendinning, D Telephone No. +49 89 2399 2443

Form PCT/IPEA/409 (cover sheet) (January 1994) BS22339. 07.02.2000

I. Basis of the report

1. This report has been drawn on the basis of (*substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments.*):

Description, pages:

1-3,5-13	as originally filed			
4,4a	as received on	08/07/1999	with letter of	08/07/1999

Claims, No.:

1-30	as received on	13/01/2000	with letter of	11/01/2000

Drawings, sheets:

1/3-3/3	as originally filed

2. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:
- ☐ the drawings, sheets:

3. ☒ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

   see separate sheet

4. Additional observations, if necessary:

III. Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

The questions whether the claimed invention appears to be novel, to involve an inventive step (to be non-obvious), or to be industrially applicable have not been examined in respect of:

- ☐ the entire international application.
- ☒ claims Nos. 28-30.

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/US97/23992

because:

☐ the said international application, or the said claims Nos. relate to the following subject matter which does not require an international preliminary examination (*specify*):

☐ the description, claims or drawings (*indicate particular elements below*) or said claims Nos. are so unclear that no meaningful opinion could be formed (*specify*):

☐ the claims, or said claims Nos. are so inadequately supported by the description that no meaningful opinion could be formed.

☒ no international search report has been established for the said claims Nos. 28-30.

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-27
	No:	Claims	
Inventive step (IS)	Yes:	Claims	1-27
	No:	Claims	
Industrial applicability (IA)	Yes:	Claims	1-27
	No:	Claims	

2. Citations and explanations

see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:

see separate sheet

I Basis of the report, and
III Non-establishment of report

New independent claim 28 claims a signal format defined by 1280 picture elements by 1080 picture elements. The person skilled in the art reading the application as first filed would not have been able to deduce from that document that a signal format as defined in new claim 28 might be regarded as an inventive concept in its own right, i.e. divorced from the technical context of the subject matter of the original independent claims. This amendment, i.e. the addition of new independent claim 28, thus goes beyond the disclosure in the international application as filed {Rule 70.2(c)}. Moreover claim 28 relates to an alleged invention in respect of which no international search report was established - for this reason, too, claim 28 has not been the subject of international preliminary examination {Rule 70.2(d)}. Dependent claims 29 and 30 fall to be considered together with independent claim 28.

V Reasoned statement under Article 35(2)

1 Independent claims 1, 13, 16 and 18 all embrace the concept of filtering a detected video signal, converting to a lower resolution and encoding the lower resolution signal. Such subject matter is not disclosed or hinted at in the prior art cited in the search report. The closest prior art is US 5,253,059 which does involve filtering and encoding a video signal, but between these two operations there is a change of frame size, rather than a change to lower resolution.

2 Independent claim 19 relates to decoding a received digital video signal which may have more than one frame resolution, one of which is 1280 x 1080 pixels per frame, whereby the resolution of the decoded signal is determined and if the determined resolution is 1280 pixels per line then the horizontal resolution is changed. There is no disclosure or hint of such subject matter in the prior art cited in the search report.

VII Certain defects in the international application

It would be appropriate to include a reference to US 5,252,059 and its disclosure in the opening pages of the description {Rule 5.1(a)(ii)}.

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PCT/US97/23992

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APR 25 2000
IS&S

PATENT COOPERATION TREATY

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From the INTERNATIONAL BUREAU

To:

APR 27 2000

TRIPOLI, Joseph, S.
Thomson Multimedia Licensing
Incorporated
P.O. Box 5312
Princeton, NJ 08540
ETATS-UNIS D'AMERIQUE

NOTIFICATION OF THE RECORDING OF A CHANGE

(PCT Rule 92bis.1 and Administrative Instructions, Section 422)

9

Date of mailing (day/month/year) 12 April 2000 (12.04.00)	
Applicant's or agent's file reference RCA 88692	**IMPORTANT NOTIFICATION**
International application No. PCT/US97/23992	**International filing date** (day/month/year) 23 December 1997 (23.12.97)

1. The following indications appeared on record concerning:

[X] the applicant [ ] the inventor [ ] the agent [ ] the common representative

Name and Address	State of Nationality	State of Residence
THOMSON CONSUMER ELECTRONICS, INC. 10330 North Meridian Street Indianapolis, IN 46290 United States of America	US	US
	Telephone No.	
	Facsimile No.	
	Teleprinter No.	

2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning:

[X] the person [X] the name [X] the address [ ] the nationality [X] the residence

Name and Address	State of Nationality	State of Residence
THOMSON LICENSING S.A. 46, Quai A. Le Galo F-92648 Boulogne Cedex France		FR
	Telephone No.	
	Facsimile No.	
	Teleprinter No.	

3. Further observations, if necessary:

4. A copy of this notification has been sent to:

[X] the receiving Office
[ ] the International Searching Authority
[ ] the International Preliminary Examining Authority
[ ] the designated Offices concerned
[X] the elected Offices concerned
[ ] other:

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland Facsimile No.: (41-22) 740.14.35	Authorized officer Catherine Massetti Telephone No.: (41-22) 338.83.38

PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : H04N 7/26

A1

(11) International Publication Number: WO 99/33273

(43) International Publication Date: 1 July 1999 (01.07.99)

(21) International Application Number: PCT/US97/23992

(22) International Filing Date: 23 December 1997 (23.12.97)

(71) Applicant (*for all designated States except US*): THOMSON CONSUMER ELECTRONICS, INC. [US/US]; 10330 North Meridian Street, Indianapolis, IN 46290–1024 (US).

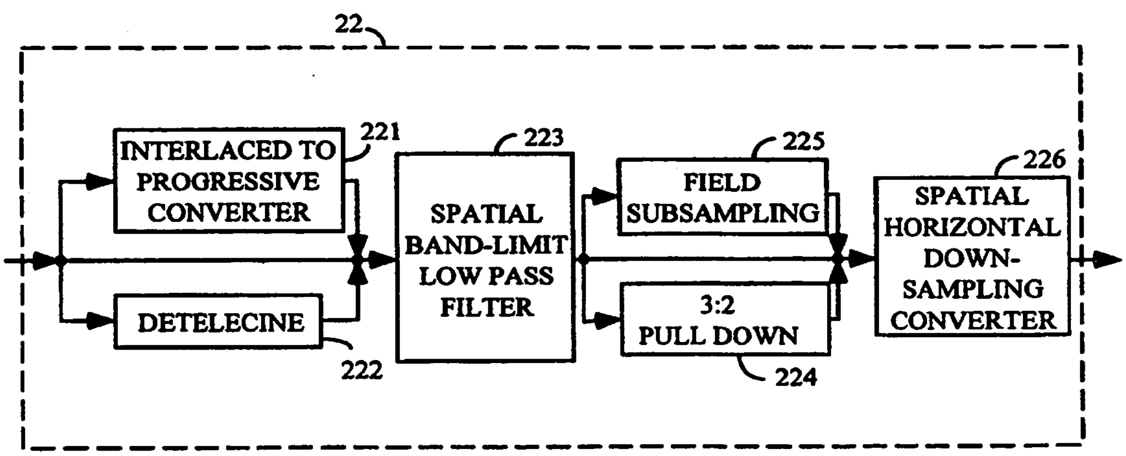
(72) Inventors; and
(75) Inventors/Applicants (*for US only*): YU, Haoping [CN/US]; Apartment 3012, 3029 West 39th Street, Indianapolis, IN 46228 (US). McNEELY, David, Lowell [US/US]; 7832 Warbler Court, Indianapolis, IN 46256 (US). BEYERS, Billy, Wesley, Jr. [US/US]; 6920 Woodcrest Drive, Greenfield, IN 46140 (US).

(74) Agents: TRIPOLI, Joseph, S. et al.; GE & RCA Licensing Management Operation, Inc., P.O. Box 5312, Princeton, NJ 08543 (US).

(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published
With international search report.

(54) Title: LOW NOISE ENCODING AND DECODING METHOD



(57) Abstract

An adaptive digital image processor (22) precedes an MPEG2 encoder (24). The processor receives a high definition (1920 by 1080 pixels per image) video signal intended for broadcast or storage, and adaptively low–pass filters the signal. The signal is subjected to low–pass two–dimensional filtering (223) to eliminate encoding artifacts and related noise. The video signal is then horizontally down–sampled (226) to create a lower resolution hybrid signal (1280 by 1080 pixels per image). A receiver decodes and decompresses the hybrid signal. The hybrid signal is upsampled to its original resolution using existing hardware and software with a software modification.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	**ES**	Spain	**LS**	Lesotho	**SI**	Slovenia
AM	Armenia	**FI**	Finland	**LT**	Lithuania	**SK**	Slovakia
AT	Austria	**FR**	France	**LU**	Luxembourg	**SN**	Senegal
AU	Australia	**GA**	Gabon	**LV**	Latvia	**SZ**	Swaziland
AZ	Azerbaijan	**GB**	United Kingdom	**MC**	Monaco	**TD**	Chad
BA	Bosnia and Herzegovina	**GE**	Georgia	**MD**	Republic of Moldova	**TG**	Togo
BB	Barbados	**GH**	Ghana	**MG**	Madagascar	**TJ**	Tajikistan
BE	Belgium	**GN**	Guinea	**MK**	The former Yugoslav Republic of Macedonia	**TM**	Turkmenistan
BF	Burkina Faso	**GR**	Greece			**TR**	Turkey
BG	Bulgaria	**HU**	Hungary	**ML**	Mali	**TT**	Trinidad and Tobago
BJ	Benin	**IE**	Ireland	**MN**	Mongolia	**UA**	Ukraine
BR	Brazil	**IL**	Israel	**MR**	Mauritania	**UG**	Uganda
BY	Belarus	**IS**	Iceland	**MW**	Malawi	**US**	United States of America
CA	Canada	**IT**	Italy	**MX**	Mexico	**UZ**	Uzbekistan
CF	Central African Republic	**JP**	Japan	**NE**	Niger	**VN**	Viet Nam
CG	Congo	**KE**	Kenya	**NL**	Netherlands	**YU**	Yugoslavia
CH	Switzerland	**KG**	Kyrgyzstan	**NO**	Norway	**ZW**	Zimbabwe
CI	Côte d'Ivoire	**KP**	Democratic People's Republic of Korea	**NZ**	New Zealand		
CM	Cameroon			**PL**	Poland		
CN	China	**KR**	Republic of Korea	**PT**	Portugal		
CU	Cuba	**KZ**	Kazakstan	**RO**	Romania		
CZ	Czech Republic	**LC**	Saint Lucia	**RU**	Russian Federation		
DE	Germany	**LI**	Liechtenstein	**SD**	Sudan		
DK	Denmark	**LK**	Sri Lanka	**SE**	Sweden		
EE	Estonia	**LR**	Liberia	**SG**	Singapore		

LOW NOISE ENCODING AND DECODING METHOD

Field of the Invention

This invention concerns image compression for reducing the bandwidth requirements of a digital video encoder.

Background of the Invention

The United States Federal Communications Commission (FCC) has approved a digital high definition television (HDTV) standard proposed by the Grand Alliance (GA), clearing the way for terrestrial digital television broadcasting in the United States. The GA HDTV system adopted the Motion Pictures Expert Group (MPEG2) video compression standard. For details, see "Information Technology - Generic Coding of Moving Picture and Associated Audio Information: Video," ISO/IEC 13818-2: 1996(E). Utilizing modern and sophisticated video compression methods, such as source processing, motion estimation and compensation, transform representation and statistical coding, an MPEG compression system can reduce the transmission bit rate by a factor of 50 or more. A full HD signal for one second requires approximately one billion bits before compression. As proposed in the GA specification, 1920 by 1080 pixel (picture element) images at a rate of 60 field per second are compressed to 18 megabits per second for digital broadcast.

The GA video compression system normally comprises two major subsystems, a pre-processor and an MPEG2 video encoder, followed by an output buffer. The input to the pre-processor is analog video in RGB format. The pre-processor digitizes the input signals and performs gamma correction on each color component to compensate for the non-linear response of the imaging camera. Gamma correction reduces the visibility of quantization noise contained in the compressed image, especially in the dark regions of the image. Then the pre-processor linearly transforms the digitized and gamma corrected RGB samples to the SMPTE 240M YC1C2 color space. Finally, the resulting chrominance components are sub-sampled to form the 4:2:0 digital video input signal. In addition to the tasks just described, the pre-processor may perform image conversion. For example, in a broadcast digital satellite system, the video signal is horizontally decimated from 720 pixels per line to 544 pixels per line to further reduce bandwidth requirements. This signal is sent to the MPEG2 video encoder.

The MPEG2 video encoder compresses the input digital video signal by removing some of the temporal redundancy between frames and some of the spatial redundancy within frames. Generally, compression is achieved by utilizing a number of different techniques in succession as described above. Adjusting the quantization precision allows the encoder to generate the compressed bit stream at any rate specified by the application. The quantization in MPEG2 systems is performed on the DCT coefficients of a data block, which may be the original image information or residual information from motion estimation. Using quantization matrices in combination with scalable quantization step sizes, the quantizer selects and quantizes only a small fraction of the DCT coefficients from every DCT block for transmission, resulting in significant data reduction. The quantization matrices can be varied on a frame basis according to the statistical distribution of the DCT coefficients and the content of the video signal. For different areas within a frame, the quantization can be fine tuned on a macroblock by macroblock basis by scaling the quantization step size based on the complexity of the macroblock. For a given output bit rate, an output buffer will provide control signals used by the encoder to adjust the quantization step size for a particular frame to maximize quantization resolution within the available bandwidth.

Ideally, the video compression system removes high frequency components which will not be perceived as missing by viewers when the image is reconstructed and displayed. The remaining low frequency components are quantized to fit within the available bandwidth. Quantization noise introduced to the signal should also be invisible to viewers upon image reconstruction. However, in a real system a trade-off is made between the information to transmit and the quantization step size for an available bandwidth. If the system does not drop sufficient coefficients for quantization, the system increases the quantization step size resulting in blocky artifacts in the reconstructed image. If the picture loses too much high frequency information during the compression process, the reconstructed image will contain other noticeable edge artifacts.

Moreover, differences in quantization between each frame causes frames within a group of pictures (GOP) to contain varying high frequency components. An I frame, for example, may have a substantial amount of high frequency coefficients dropped during encoding, whereas P and B frames retain high frequency components corresponding to those dropped in the I frame. The reconstructed GOP will now contain artifacts because the high frequency information varies between frames used to reconstruct each other.

These problems occur within the GA system as currently defined. Compressing the HD image signal further only decreases displayed picture quality. Satellite broadcast providers are unwilling to transmit HD signals because only one program can be transmitted at a time in a transponder. To date, compressing an HD program sufficiently to fit two programs in one satellite channel (for example, 24 MHz 4-PSK Modulation) at the same time results in unacceptable viewer picture quality. Therefore, satellite broadcast providers are hesitant to broadcast HDTV due to inefficient use of the channel. Likewise, terrestrial broadcast providers

are reluctant to commit to providing full HD programs when one program fully occupies a channel in which several SD programs can reside.

Summary of the Invention

In accordance with the principles of the present invention, a digital image processor identifies a video signal type, and selectively converts the original signal format to a different format as necessary. The converted signal is filtered and reconverted to the original format as necessary. The filtered signal is converted to a lower resolution and compressed to a target bit rate. Finally, the compressed signal is conveyed to an output data channel.

Brief Description of the Drawings

Figure 1 shows one configuration for a video compressor in accordance with the present invention.

Figure 2 shows detail of unit 22 from Figure 1.

Figure 3 shows one possible response of an adaptive filter included in unit 22.

Figure 4 is a flow chart of an exemplary transmitting system using the present invention.

Figure 5 is a flow chart of an exemplary receiving system using the present invention.

Description of the Preferred Embodiment

An MPEG2 encoder including apparatus according to the principles of the present invention includes a two dimensional (vertical and horizontal, for example) filter prior to the encoder. The encoder, the output buffer and the filter each produce information which may be utilized by the other units to improve overall efficiency. Such information concerns image motion, image contrast, quantization matrix selection, scale factor selection, bit rate out of each unit, image texture, for example. The information is communicated between the units by a controller which oversees the encoding process, or by individual controllers resident in each unit.

The controller evaluates the incoming information and identifies commonalties over a group of pictures, a frame, or a partial frame which can be advantageously used to modify the operation of the filter and/or the encoder to efficiently encode the group, frame or partial frame

to the target bit rate. Generally, the filter is adjusted because adjusting the filter induces less noise than adjusting the encoder. Also, the filter is actually a set of filters which allows the greatest flexibility by adjusting individual filter coefficients as needed. These filters are a horizontal anti-aliasing low-pass filter, a vertical low-pass filter, and a two-dimensional low-pass filter, generally in the sequential order just given. The controller evaluates the received information against current filter and encoder setup, and makes adjustments to one or more filers and/or to the encoder according to one or more predominant commonalties. The end result is that the input signal is low-pass filtered by the filter in a manner which generally allows the encoder to encode the image uniformly across a group of pictures, a frame, or a partial frame relative to a dominant commonality of the data being uniformly encoded.

The encoded signal may be transmitted in the available bandwidth, and then reconstructed and displayed without artifacts which would have been present otherwise. For high definition signals having 1920 by 1020 pixels per image frame, the horizontal resolution is reduced to 1280 pixels per line after filtering and before encoding to further reduce the bandwidth of the transmitted signal. The result is a hybrid image resolution which HD receivers can receive, decode and display with a minor software change.

An exemplary configuration of the video compression system according to the present invention is shown in Figure 1. An input video signal is received by movie detector 20, which identifies if the signal is a movie (film) signal which has been reformatted by telecine methods from 24 frames per second to 30 frames per second. The reformatted movie signal is directed to the appropriate section of adaptive image processor 22 as will be described. If the input signal is not a reformatted movie signal, the signal passes to another section of adaptive image processor 22. Identification of telecine movie signals occurs by known methods.

Processor 22 receives control information from output buffer 26 and from MPEG2 encoder 24 via controller 28, and filters image frames so that the encoder 24 can efficiently encode the frame to be within the available bit rate, and to be generally free of noticeable artifacts. Processor 22 filters the signal in two dimensions (2-D) (for example, horizontal and vertical) as needed to improve the reconstructed image quality of a MPEG2 encoded bit stream constrained to an average bit rate. The goal is to modify local 2-D frequency content of the source to improve MPEG2 coding efficiency in a manner least injurious to the MPEG2 reconstructed image with regard to image sharpness and encoding artifacts. Filtering of the signal can be done on predetermined data, for example, a group of pictures (GOP) or frames, a single frame, or pixel by pixel.

The 2-D filter low-pass filters the image. Optimally, the high frequency information which is removed is either redundant or not noticeable to the viewer. In practice, to attain the desired bit rate, some high frequency information may be removed which is noticeable to a viewer. However, a system which includes a processor 22 before MPEG2 encoding generates an image which is superior to a system without a processor 22, as will be discussed.

The filtered signal is encoded by MPEG2 encoder 24, which receives image parameters from processor 22 and output buffer 26 via controller 28, and adjusts MPEG2 compression to comply with available bit rate. Compression occurs in the same manner as described in the GA specification. Encoder 24 sends the compressed data to output buffer 26. Buffer 26 provides the compressed data at a predetermined rate to be transport encoded, modulated, and transmitted via a transmission channel using known signal processing techniques. Prior to modulation, the compressed signal may be sent to a statistical multiplexer to be multiplexed with multiple programs for transmission on a single channel. Signal processing units after buffer 26 are well known and therefore are not shown in Figure 1 to simplify the drawing.

The video compression system can be configured to accept any type of video signal. The system of Figure 1 is configured to accept both television (camera) and movie (film) programs formatted to known industrial standards. One common configuration would be for the system of Figure 1 to receive the output from a pre-processor as previously described in the background, for example. The system may be configured to accept other types of video signals by adding appropriate hardware and/or software. These configurations are not shown to simplify Figure 1.

Movie detector 20 recognizes the presence of certain relationships in the input signal that can be used to improve coding efficiency: (Type 1) 60 Field/Second Interlaced Scanned Source, (Type 2) 60 Field/Second Interlaced Scanned 30 Frame/Second Movie, (Type 3) 60 Field/Second Interlaced Scanned 24 Frame/Second Movie, (Type 4) Progressive Scanned Source, (Type 5) 60 Frame/Second Progressive Scanned 30 Frame/Second Movie, and (Type 6) 60 Frame/Second Progressive Scanned 24 Frame/Second Movie. Detection occurs in response to an external control signal (not shown) or by known techniques such as those used in current standard definition (SD) MPEG2 encoders. Signal format information is passed with the signal to adaptive image processor 22, as is described below. Movie detector 20 also detects whether the signal is interlaced scan or progressive scan type and passes that information to processor 22. These scan types are exemplary and define parameters by which signals are directed through processor 22. Implementations for other field and frame rates may also be used.

Adaptive image processor 22 performs several programmable functions which reduce the amount of data to be compressed by encoder 24. Processor 22 operates on each frame, in general, so that the processed frame can be optimally encoded to eliminate or greatly reduce noise which is noticeable to the viewer. Processor 22 may generally be viewed as a spatial varying 2-D low-pass filter, because it down-samples each image frame spatially and adaptively filters selected 2-D high frequency components from the signal. The adaptive filtering can be adjusted over a series of frames, for a single frame, or pixel-by-pixel to produce a processed frame.

Processor 22 can facilitate encoding for any type of signal. However, for this embodiment, processor 22 is programmed to operated on HD data as defined by the GA specification. This can be either 1920 by 1080 pixels per image or 1280 by 720 pixels per

image. According to the GA specification, each HD format requires approximately 18 megabits per second for broadcast. To simplify the discussion, only the 1920 by 1080 format will be discussed in detail. The discussion is equally applicable for the 1280 by 720 format or any other format.

Figure 2 shows details of adaptive image processor 22. Depending on signal format information received from detector 20, the image signal is routed by controller 28 (Figure 1) to an interlaced to progressive converter 221 (Type 1), a de-telecine unit 222 (Type 2,3), or passed through unmodified (Type 4-6) to a spatial band-limit, low-pass filter 223. Filter 223 receives the output of units 221 and 222 after these units have processed the signal.

Converter 221 receives the signal if its format contains 60 Hz interlaced fields and converts the signal to progressive frames at the rate of 60 frames per second. A progressive frame includes all the image information in each frame. Filtering a progressive scan signal typically does not introduce artifacts such as may occur when filtering field information of an interlaced signal. Converter 221 utilizes known methods to convert interlaced fields to a progressive frame.

De-telecine unit 222 eliminates the redundant fields of a 60 Hz interlaced scanned movie and reconstructs the original progressive scanned movie. The progressive format allows subsequent vertical low-pass filtering to be free of motion artifacts. If a movie source (type 2 or type 3) input were processed as a type 1 source, vertical low-pass filtering would degrade the ability of the MPEG2 encoder to detect and properly process movie source material. Coding efficiency would suffer. Unit 222 converts the signal to a progressive format and removes the redundant fields/frames before filtering because filtering may filter the redundant information differently. If the redundant information is not removed before filtering the information may not be identical after filtering, and the encoder may not recognize the signal as a Type 2/3 signal. Then the encoder would encode information which otherwise would have been removed due to the redundancy.

Also, the design of processor 22 is simplified by providing a single output clock from unit 222. If unit 222 provides output progressive film images at a rate of 24 frames per second and 30 frames per second, two output clocks and supporting circuitry would be required.

Signals which were originally generated in a 30 frames per second progressive format pass directly to filter 223. Filter 223 expects video information represented as complete image frames. Spatial, low-pass filter 223 is actually a set of filters. For example, the first filter is an anti-aliasing, horizontal low-pass filter. The second filter is a vertical low-pass filter. The final filter is a 2-D low-pass filter as previously described. The coefficients of each filter tap may be adaptively set according to control information from encoder 24 and buffer 26 as seen in Figure 1. The progressive signal is low-pass filtered horizontally to eliminate aliasing from subsequent down sampling in sample rate converter 226. The final horizontal output of the 1920 pixels per line will be 1280 pixels per line, as will be discussed. To eliminate alias noise within the final signal, low-pass filter 223 has a cut off frequency of 640 cycles per line. The

horizontal anti-alias filter included in unit 223 may be a 17 tap finite impulse response (FIR) filter with the following tap coefficients:

[f0, f1,...,f15, f16] = [-4, 10, 0, -30, 48, 0, -128, 276, 680, 276, -128, 0, 48, -30, 0, 10, -4]/1024.

Encoding HD video signals at a reduced bit rate normally requires additional vertical low-pass filtering to further reduce the bandwidth of the video signals. Removing vertical high frequency energy before MPEG encoding is necessary to achieve acceptable overall picture quality. Vertical frequency regions of highest phase sensitivity are attenuated. The vertical cut off frequency is set to some fraction of the Nyquist frequency. For example, a cut off frequency equal to approximately half the line rate of the HD input signal may be appropriate for some video material. For an HD signal with 1080 lines/picture height (l/ph), this would correspond to a cut off of 540 l/ph. This frequency may be programmable, and a programmable cut off frequency would be determined by controller 28 from parameters available from encoder 24 and buffer 26 of Figure 1 (i.e. desired bit rate, quantization matrices, etc.). The vertical low-pass filter included in unit 223 may be a 17 tap FIR filter with the following tap coefficients.

[f0, f1,...,f15, f16] = [-4, -7, 14, 28, -27, -81, 37, 316, 472, 316, 37, -81, -27, 28, 14, -7, -4]/1024.

As an alternative, the cut off frequency may be equal to twice the line rate of an SD signal. Generally, the vertical low-pass filter follows the horizontal anti-alias filter.

Processor 22 performs vertical filtering rather than vertical decimation, thereby maintaining constant vertical line resolution. Currently, filtering is preferred over decimation for interlaced video signals. Converting vertical line resolution for an interlaced image sequence requires complex hardware and software, resulting in high receiver costs. Vertical sample rate conversion compromises vertical high frequency performance because of the increasing tap complexity combined with Nyquist sampling (i.e., no oversampling). Cost considerations at the receiver currently discourage reducing vertical resolution to reduce artifacts and the encoded bit rate. The displayed picture would be significantly degraded by employing the current technology in vertical sample rate converters in place of the vertical low-pass filter described above. However, efficient and cost effective vertical sample rate converters may replace the vertical filter described herein without departing from the principles of the present invention.

The coefficients for both the horizontal and vertical low-pass filters can be modified by software, and applied to the pixel level, if necessary, to attain the target bit rate without generating artifacts in the reconstructed image. Generally, coefficient modification on a frame basis is sufficient. An alternative for slower processors is to preprogram a number of different coefficient sets for the filters and select the most appropriate set for the image information

being processed. The greater flexibility of the adaptive filters enables the overall system to produce a data stream with fewer artifacts relative to a system without adaptive filters.

After the signal has been low-pass filtered in the horizontal and vertical directions by unit 223, controller 28 determines whether the signal can be uniformly encoded by encoder 24 on a frame basis without introducing significant quantization noise. If so the signal passes to either unit 224, 225 or 226 depending upon its format, as will be discussed. If, however, the encoding process is likely to introduce noise and/or artifacts into the signal, it is sent to a two dimensional low-pass filter in unit 223 for further adaptive filtering. Control parameters from processor 22, encoder 24, and output buffer 26 (Figure 1) allow controller 28 (or an individual unit controller in unit 223) to determine if further filtering is needed. Control parameters used to make this determination are, for example, measurements of motion and contrast, available quantization tables, encoding efficiency and the current target bit rate.

The 2-D filter in unit 223 reduces high frequency information from an image frame primarily along the diagonal, instead of the horizontal or vertical directions alone. The human eye is very sensitive to high frequency noise in the vertical and horizontal directions relative to the diagonal directions. Removing sufficient high frequency information diagonally to allow uniform quantization by encoder 24 generally results in a better quality signal with less observable noise. The diagonal filter, like all previous filtering, operates on an entire image frame and is programmable.

The diagonal filter may be compatible with the quantization matrices in the encoder. Quantization matrices often use diamond shaped matrices for I frame quantization. However, these matrices often induce noise because B and P frames use other types of quantization matrices which retain the high frequency components during the compression and motion compensation process which occurs in encoder 24. The filters of processor 22 remove high frequency information from each image frame before MPEG2 encoder 24 processes the data into I, P and B frames in a motion estimation network. Therefore, high frequency components are generally eliminated from the P and B frames as well as from I frames. On reconstruction, the image is generally free from artifacts created by MPEG2 encoding as known.

Referring to Figure 1, in practice, the controller 28 evaluates signal parameters, (e.g., motion, contrast, etc.) before filtering a given frame by processor 22, and determines the coefficient settings for all filters in unit 223, including diagonal filtering needed. During the filtering process of a given frame, controller 28 monitors signal parameters from processor 22, encoder 24 and buffer 26 and changes coefficients as necessary to maintain the target bit rate with minimal artifacts/noise. Each frame is filtered based upon the most recent signal parameters and is passed to encoder 24 for compression, and then to buffer 26 as subsequent information is input into filter 223.

If the signal originated as a 24 frame per second movie signal, the filtered signal is applied to 3:2 pull down unit 224. Unit 224 duplicates selected frames to provide a 30 frames

per second output signal. This occurs by known methods. Then the signal passes from unit 224 to horizontal down-sampling converter 226.

Field sub-sampling unit 225 converts progressive signals from filter 223 from progressive to interlaced scan format. This conversion is accomplished by known methods. Without conversion back to interlaced format, the signal would contain twice the amount of data, because the progressive frame rate from unit 221 is 60 Hz. The interlaced signal is applied to converter 226.

Sample rate converter 226 receives progressive signals at 30 frames per second directly from filter 223. Also, units 224 and 225 provide signals to converter 226 as described above. Converter 226 down samples HD signals to the transmission format selected. This format does not need to be a standard format. It may be any image ratio and frame size that is desired. A non-standard format will require receiver modification, however.

When converter 226 receives 1920 by 1080 GA HDTV signals, converter 226 down samples the horizontal information and outputs a hybrid pixel frame format of 1280 by 1080. GA HDTV compatible receivers are capable of receiving image frames containing 1920 by 1080 pixels and 1280 by 720 pixels. Therefore, GA compatible receivers may be modified to support 1280 pixels horizontal resolution and 1080 pixels vertical resolution. Compatible receiver hardware upsamples 1280 horizontal pixels to 1920 horizontal pixels in conjunction with an increase in vertical resolution. However, GA compliant receivers are not required nor programmed to receive an image frame resolution of 1280 by 1080 pixels (horizontal by vertical) as a defined format. The hardware is in place to receive and decode this resolution, but the supporting software to decode and to increase only horizontal resolution must be added. Adding the software is simple and inexpensive relative to redesigning and adding new hardware needed for other non-standard formats.

Processor 22 provides the hybrid 1280 by 1080 format because current display technology is incapable of displaying 1920 pixels/line resolution. Currently, the best television monitors can only display resolution to approximately 1200 to 1300 pixels/line. Therefore, limiting the output resolution to 1280 pixels/line in the horizontal direction has little if any adverse effect on picture quality. By providing a display resolution (1280 by 1080) which is supported by existing decoding and decompressing receiver hardware, receiver manufacturers will be minimally impacted because only a software change is necessary. For certain receivers, such as for broadcast satellites, the software modification can be downloaded and installed remotely via a satellite link. For these receivers there is no need for a service technician to become involved.

The hybrid format is advantageous because terrestrial and satellite program providers have been unwilling to transmit HD programs. A satellite transponder transmits a data stream of approximately 24 Mbits per second (Mbps). A terrestrial HDTV broadcasts can transmit up to 19 Mbps including the HD program at 18 Mbps and other information (such as audio, program guide, conditional access, etc.). Present satellite transponders can each carry at most

one HDTV program, which satellite program providers contend is not sufficiently profitable. Simply reducing the horizontal frame resolution from 1920 to 1280 is not sufficient to allow the simultaneous transmission of two HD programs on a single satellite transponder. The filtering provided by processor 22 advantageously permits such dual HD transmission on a single channel.

The filtering characteristic provided by processor 22 may have various shapes, including diamond, cross, and hyperbolic from axis to axis, where for each filter the filtering is diagonal. One possible shape, 2-D Hyperbolic, is particularly advantageous in this application and has an amplitude-versus-frequency response as illustrated in Figure 3. The adjustable filter cutoff frequency generally is set to allow the GOP, the frame or the partial frame chosen to be compressed uniformly by encoder 24. If necessary, additional horizontal and vertical high frequency information may be filtered, but this is generally not needed. As the picture complexity changes, or as the available bit rate increases, the amount of data filtered by the diagonal filter and other previous filters decreases. The 2-D filter could be described, for example, as a two dimensional FIR with 13 taps in each direction (13 by 13), or as a 2-D infinite impulse response (IIR) filter.

The 2-D FIR filter included in unit 223 may be a 13 by 13 tap filter with the following tap coefficients:

0	0	0	1	-3	5	-5	5	-3	1	0	0	0
0	0	1	-1	-3	9	-11	9	-3	-1	1	0	0
0	1	-1	-4	4	6	-13	6	4	-4	-1	1	0
1	-1	-4	1	14	-13	4	-13	14	1	-4	-1	1
-3	-3	4	14	5	-47	61	-47	5	14	4	-3	-3
5	9	6	-13	-47	-55	193	-55	-47	-13	6	9	5
-5	-11	-13	4	61	193	556	193	61	4	-13	-11	-5
5	9	6	-13	-47	-55	193	-55	-47	-13	6	9	5
-3	-3	4	14	5	-47	61	-47	5	14	4	-3	-3
1	-1	-4	1	14	-13	4	-13	14	1	-4	-1	1
0	1	-1	-4	4	6	-13	6	4	-4	-1	1	0
0	0	1	-1	-3	9	-11	9	-3	-1	1	0	0
0	0	0	1	-3	5	-5	5	-3	1	0	0	0

For these coefficients, the DC gain is 1024. The coefficients exhibit octant symmetry which gives 28 independent coefficients. Symmetrical coefficient regions allows faster setup of the adjustable filter. It is possible, however, that each octant be different if, for example, an image or region being filtered exhibited different characteristic in one part of the image.

The filter response of processor 22 can vary continuously from one set of coefficients to another on a pixel to pixel basis. Thus, processor 22 may exhibit different operating parameters for maintaining good image quality under bit rate constraint, as will be discussed.

As mentioned previously, processor 22 can be adaptively modified to filter adaptively depending upon the parameter(s) used to define the filter adaptation. For example, variance in an image frame can be used to segment the image into regions for different processing. Edges are an important image feature in that dominant edges mask coding errors in their vicinity, and they can also define image regions. Colorimetry may be used to identify areas of low complexity, such as flesh and sky. Textures may be identified and processed as a region as well. Textures are generally less important than edges. Textures, therefore, identify regions which may be filtered more that other regions. Also, cinematic composition can be used to locate important figures or action which require higher coding efficiency and, thus, less filtering. Background is generally softened by the depth of field of the camera optics and may be more heavily filtered. Pan and scan information may be used to define the center of interest of an image for different processing by processor 22.

The operation of encoder 24 is compatible with the MPEG2 standard. Encoder 24 may provide information via controller 28 which processor 22 may use to enhance performance. Such information may include the bit rate information, for example. This bit rate information may comprise the average bit rate for a GOP, the frame bit rate, and the macro-block or block bit rate. Other information which may enhance the performance of processor 22 includes the discrete cosine transform complexity, the type quantization matrix being used, and the quantization matrix step size being used. Also, processor 22 may provide information to encoder 24 via controller 28 to adjust its operation to improve encoding performance.

After being formed into a transport packet data stream using known techniques, the HD signal is transmitted to a receiver in a known manner, e.g.., as described in the Grand Alliance specification. Except for the required up-sampling to a full HD pixel resolution at the receiver, the signal processing provided by processor 22 is transparent to a decoder in a Grand Alliance compatible receiver.

At the receiver, the data stream is demodulated and the transport stream is processed to recover the data packets and program information using known techniques. For HD programs in the hybrid format described above, the signal is upsampled in the horizontal direction in the display processor if the display requires a full HD signal. The number of vertical lines in the image signal is unchanged. This reconstructs the full HD signal of 1920 by 1080 resolution for display by a high definition image reproducing device. If the image display device requires less than a full HD signal, the signal is appropriately down sampled during image reconstruction before display by known methods. Existing receivers which are Grand Alliance compatible require a software modification to be able to reconstruct the hybrid signal. The software modification allows horizontal and vertical hardware and software processing routines assigned

to Grand Alliance standardized modes to be independently selected as needed for the incoming signal.

Figure 4 is a flow chart of the video image signal flow through the encoding system. In step 30, the signal format is identified and the identifying information is conveyed with the video signal. The format information may indicate, for example, whether the signal is originally from a movie with a 24 frame per second format, and whether the signal is interlaced or progressive. If the video signal is interlaced, the signal is converted to a progressive signal at 60 frames per second in step 31. If the signal has been converted by 3:2 pull down, the redundant frames are removed in step 32. If the video signal is already in a camera progressive format it passes directly to the filter of step 34. In step 34, the video signal is spatially low-passed filtered. This includes vertical, horizontal and diagonal filtering as described above. Step 35 reconverts the progressive signal, which was converted from and interlaced signal in step 31, back to an interlaced signal. In step 36 the signal is subjected to 3:2 pull down to replace redundant frames previously deleted in step 32. Video signals passing directly from step 30 to step 34 above now pass directly from step 34 to step 38. In step 38, the video signal from one of steps 34, 35 and 36 is subsampled to the hybrid 1280 by 1080 HD signal resolution defined above, or to another output format as desired. In step 40, the hybrid signal is MPEG2 encoded as previously described. Step 42 transport processes the encoded signal, and step 44 modulates the transport signal as required for transmission via an output channel, such as an RF terrestrial broadcast channel. Finally, step 46 transmits the modulated signal. Steps 42 to 46 occur by known methods.

Figure 5 is a flow chart of the transmitted image signal flow through a receiver. This flow chart assumes that the image resolution of the received signal is the hybrid 1280 by 1080 HD signal defined above. In step 50, the transmitted signal is received by a tuner and demodulated. The demodulated signal is MPEG2 decoded and decompressed in step 52. Step 54 identifies the video signal resolution as 1280 by 1080 pixels per image via control information sent with the signal. The Grand Alliance MPEG2 protocol supplies image resolution information with the transmitted signal. The hybrid signal is generally identified by a unique code as is any other defined resolution. The hybrid signal could also be defined otherwise, for example, by information in the user data of the transmitted data. The hybrid video signal is horizontally upsampled to a full 1920 by 1080 HD signal during display processing in step 56. The hybrid signal is upsampled with new software in association with existing hardware and software resident in the receiver as previously described. Finally, the full HD video signal is displayed on a 1920 by 1080 display in step 58. Steps 50, 52 and 58 employ known methods.

The apparatus and methods described above can be applied in a number of configurations to achieve an improved image reconstruction for high definition display. Adaptive and non-adaptive options may be used depending on the requirements of a particular system. Some of these options are discussed below.

A non-adaptive strategy would be to set frame filtering of processor 22 to a target bit rate and allow all images to be processed uniformly. Another non-adaptive strategy would make the assumption that the center of a displayed image is the most interesting region. This also assumes that peripheries of the image are less interesting and therefore less important to the viewer. The coefficients of the filters of processor 22 are set by controller 28 via parameters which are functions of pixel spatial position and all image information is uniformly processed.

An adaptive option is to segment the image into regions using texture model parameters, local video variance, colormetrics, or other picture complexity measures based on the source image. Filtering characteristics of processor 22 are adaptively modified for different regions.

Another approach is to adaptively modify the filtering characteristics of processor 22 as a function of the difference between the actual bit rate and the target bit rate. In this case, a single parameter controls transition in filter coefficients for the 2-D frequency response.

Another strategy is to design the 2-D frequency response of the filtering provided by processor 22 to be compatible with the quantization matrix employed by encoder 24. A quantization matrix may be viewed as a low-pass filter which has 2-D shape. For this strategy the values of the filter coefficients would be a function of the quantization matrix step size. As the step size is changed according to known encoder operation, a corresponding change would occur for corresponding filter coefficients.

The options noted above illustrate the flexibility of a system employing the principles of the invention. Such a system preferably operates within the context of MPEG2 rate control to extend the MPEG2 compression capability by reducing encoding artifacts and other noise. The versatility and economics of HDTV deployment is improved through the use of the invention. The number of HD programs transmitted per transponder in a direct broadcast satellite system (i.e., 24 MHz 4-PSK) is increased from one to two programs, or one HD program with multiple SD programs. The ability to transmit one HD program with multiple SD programs in a 6 MHz terrestrial broadcast channel is attainable in accordance with the principles of the present invention. Previously, broadcasters were limited to transmitting one HD program in one channel, or multiple SD programs in one channel.

Although the invention has been described in the context of HD signal transmitting and receiving systems, the principles of the invention are applicable to other arrangements such as data storage systems. In systems such as digital video disk (DVD), video data is encoded and stored for replay at a later time. The storage medium has a limited amount of storage space available. If an encoded program, a movie, or other video sequence exceeds the amount of space available on the medium, further encoding/compression to make the program fit may create unacceptable artifacts. The invention described above may be used to efficiently encode the program to a lower bit rate allowing the program to fit on the disk. Or, multiple programs may now fit on one disk. Digital storage onto tape may also benefit as describe above.

CLAIMS

1. A method for processing first and second video signals respectively exhibiting first and second dissimilar image formats, comprising the step of detecting the presence of said first or second video signal, and further comprising the steps of:

A. when said first video signal is detected,

(a) converting said first video signal to a different format, to produce a converted signal;

(b) filtering said converted signal to produce a filtered signal;

(c) reconverting said filtered signal to the original format of said first signal, to produce a reconverted signal;

(d) converting said reconverted signal to a lower resolution to produce a lower resolution signal;

(e) encoding said lower resolution signal to produce an encoded signal; and

(f) conveying said encode signal to an output channel; and

B. when said second video signal is detected,

(g) filtering said second video signal to produce a filtered signal;

(h) converting said filtered signal to a lower resolution to produce a lower resolution signal;

(i) encoding said lower resolution signal to produce an encoded signal; and

(j) conveying said encode signal to an output channel.

2. The method of claim 1, wherein:
said first video signal is an interlaced scan signal, and said interlaced scan signal is converted to a progressive scan signal in step (a).

3. The method of claim 1, wherein:
said first video signal is a telecined film signal, and said telecined film signal is converted to de-telecined signal in step (a).

4. The method of claim 1, wherein:
said second video signal is a progressive scan signal.

5. The method of claim 1, wherein:
said filtering steps provide low-pass filtering.

6. The method of claim 5, wherein:
said filtering steps provide two-dimensional filtering.

7. The method of claim 1, wherein:
said filtering steps provide adaptive filtering adjusted to one of a group of picture frames, a single frame, and a part of a frame.

8. The method of claim 1, wherein:
said filtering steps provide temporally low-pass filtering and adaptively change filtering characteristics in response to characteristics of said signal.

9. The method of claim 1, wherein:
said filtering steps provide spatially low-pass filtering and adaptively change filtering characteristics in response to characteristics of said signal.

10. The method of claim 1, wherein:
said encoding steps are MPEG2 compatible.

11. The method of claim 1, wherein:
said lower resolution signal has a resolution of 1280 by 1020 data samples per frame.

12. The method of claim 1, wherein:
said first and second video signals are high definition signals having a resolution of 1920 by 1080 data samples per frame.

13. A method for processing one of an interlaced scan video signal and a telecined film format signal, comprising the steps of:
detecting the presence of one of said interlaced scan video signal and said telecined film signal,
converting said detected signal to one of a progressive scan signal and a de-telecined signal, respectively, to produce a converted signal;
filtering said converted signal to produce a filtered signal;
reconverting said filtered signal to one of an interlaced scan signal and a telecined signal, respectively, to produce a reconverted signal;
converting said reconverted signal to a lower resolution to produce a lower resolution signal;
encoding said lower resolution signal to produce an encoded signal; and
conveying said encoded signal to an output channel.

14. The method of claim 13, wherein:
said filtering step is low-pass filtering, and said encoding step is MPEG2 encoding.

15. The method of claim 13, wherein:
said lower resolution signal has a resolution of 1280 by 1020 data samples per frame.

16. A method for processing a non-telecined progressive scan video signal, comprising the steps of:
filtering said detected signal to produce a filtered signal;
converting said filtered signal to a lower resolution to produce a lower resolution signal;
encoding said lower resolution signal to produce an encoded signal; and
conveying said encode signal to an output channel.

17. The method of claim 16, wherein:
said filtering step is low-pass filtering, and said encoding step is MPEG2 encoding.

18. The method of claim 16, wherein:
said lower resolution signal has a resolution of 1280 by 1020 data samples per frame.

19. In a high definition video signal processing system, a method for processing a received digital video signal subject to exhibiting more than one image resolution, including a resolution of 1280 by 1020 data samples per frame, comprising the steps:
decoding said signal to produce a decoded signal;
determining the image resolution of said decoded signal;
converting horizontal information from said decoded signal to a different resolution if said decoded signal has a horizontal image resolution of 1280 samples per line, to produce a converted signal; and
conveying said converted signal to an output device.

20. The method of claim 19, wherein:
said conversion is up-conversion, and said different resolution is 1980 horizontal samples per line.

21. The method of claim 19 wherein:
said conversion is down-conversion, and said different resolution is a lower resolution.

22. The method of claim 19, wherein:
said received digital video signal is MPEG2 compatible.

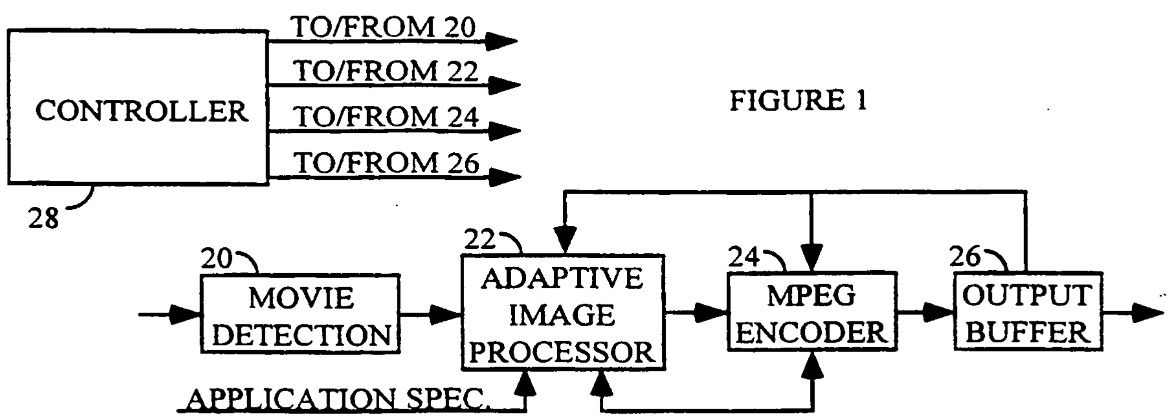


FIGURE 1

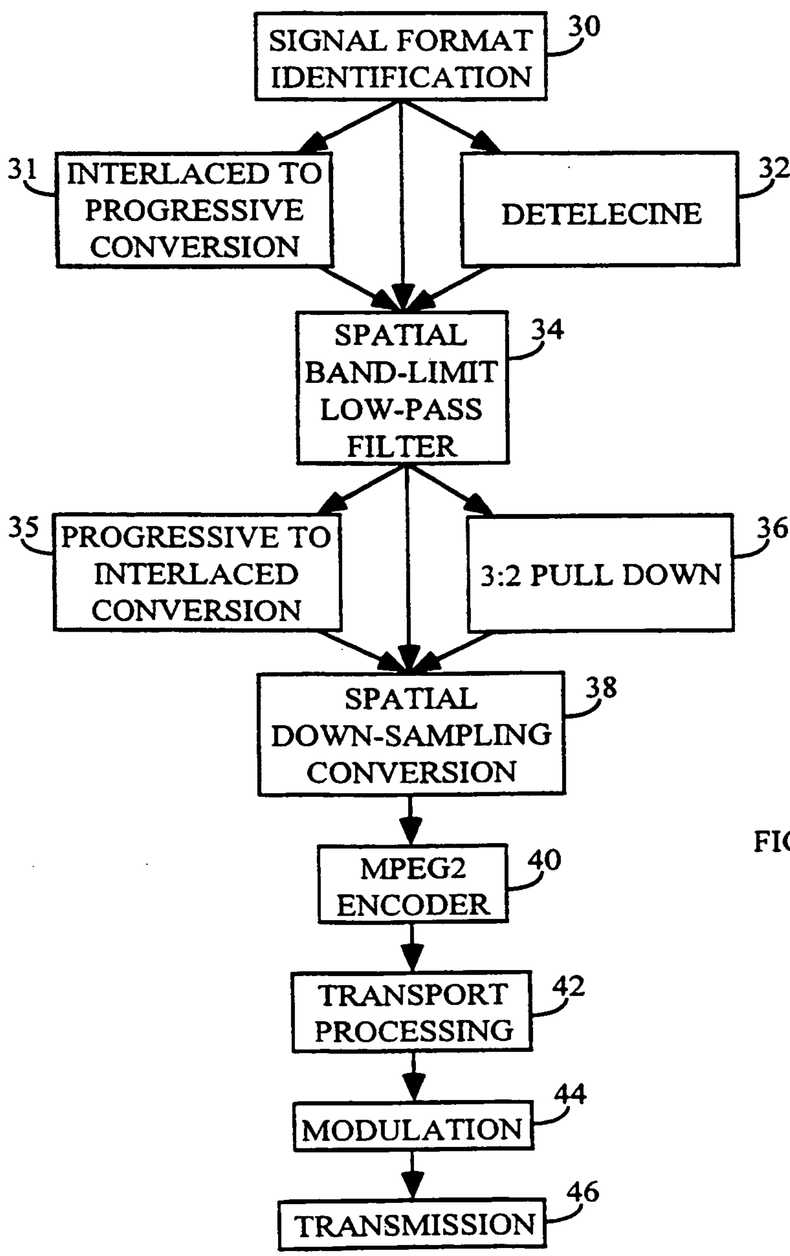


FIGURE 4

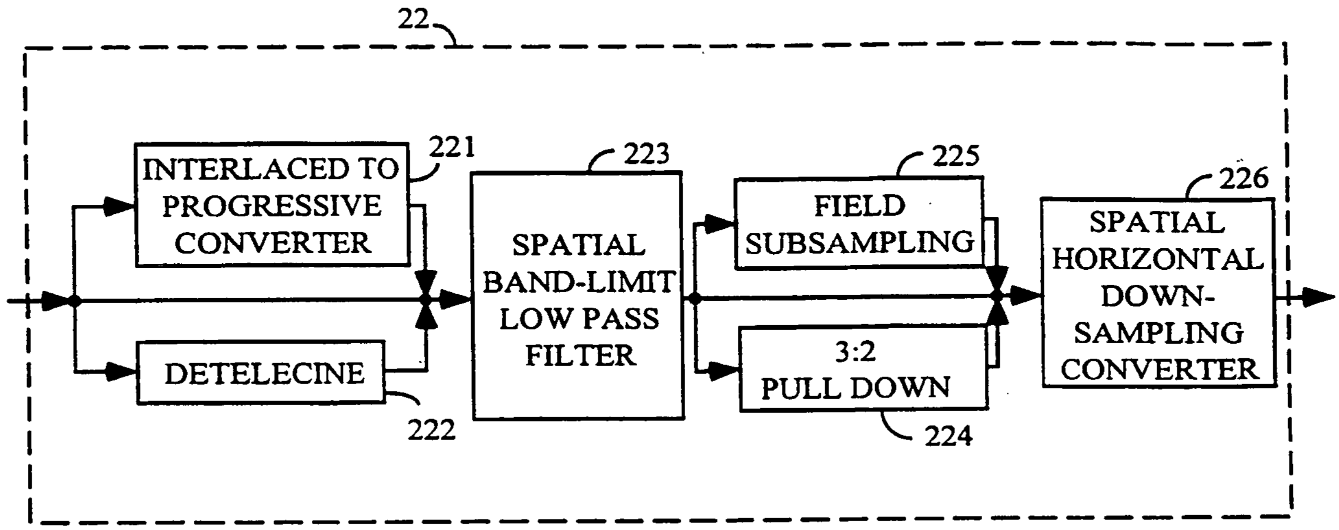


FIGURE 2

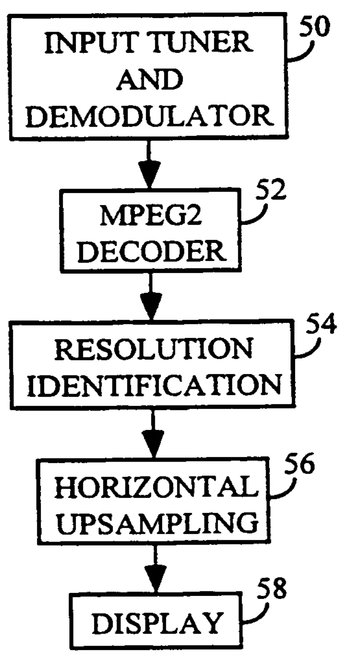


FIGURE 5

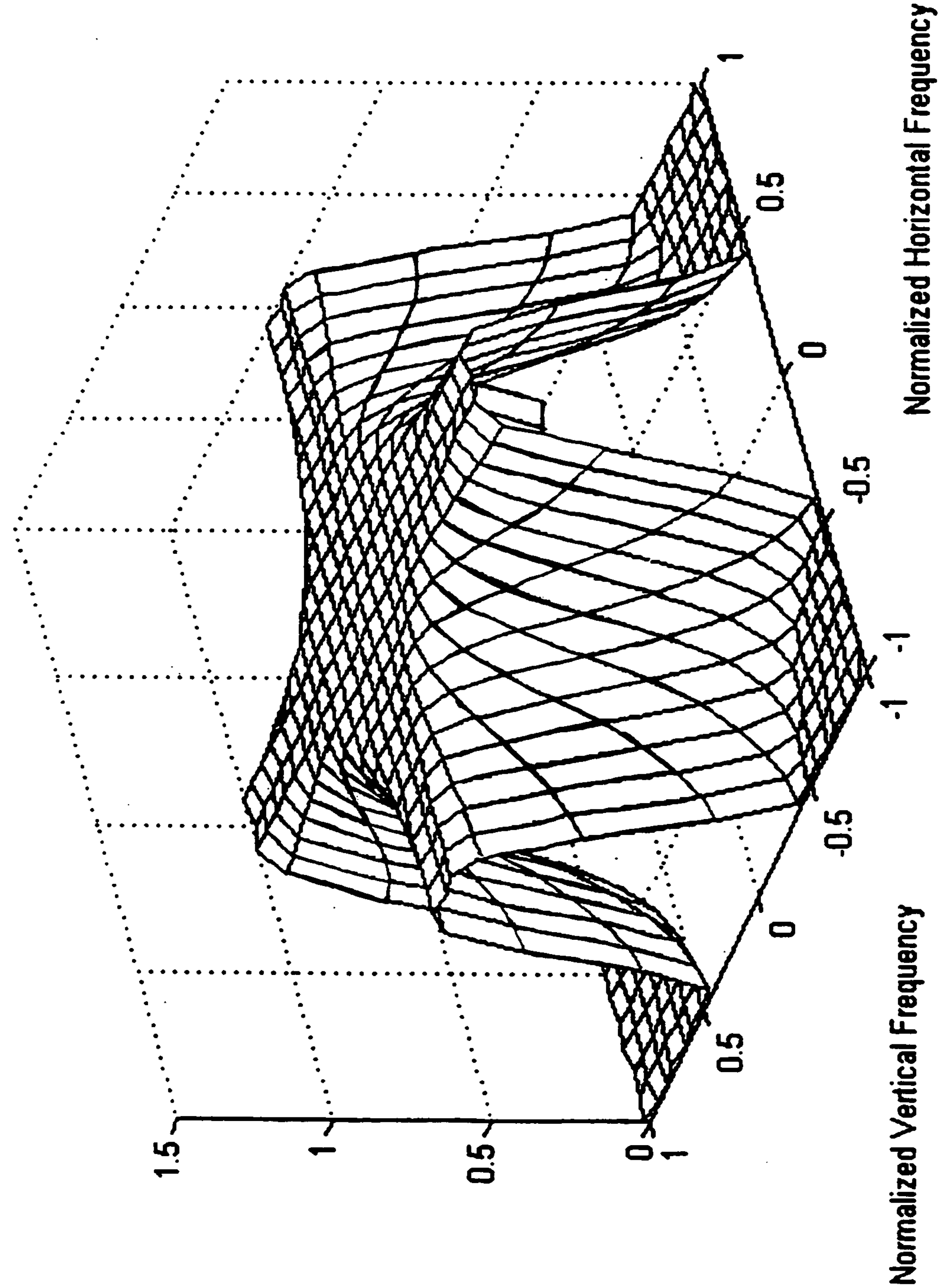

1.5
1
0.5
0
1
0.5
0
-0.5
-1
-1
-0.5
0
0.5
1
Normalized Vertical Frequency
Normalized Horizontal Frequency

FIGURE 3

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 97/23992

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04N7/26

According to International Patent Classification(IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 253 059 A (ANSARI RASHID ET AL) 12 October 1993	16-18
A	see column 3, line 25 - column 4, line 33; figure 1 ---	1,13
X	US 5 049 993 A (LEGALL DIDIER J ET AL) 17 September 1991	16
A	see column 6, line 58 - column 7, line 8; figures 1,6 ---	1,13
A	US 5 530 484 A (BHATT BHAVESH B ET AL) 25 June 1996 see column 2, line 55 - column 5, line 65 ---	19
A	EP 0 595 323 A (SONY CORP) 4 May 1994 see column 6, line 37 - column 12, line 22 ---	1,13
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[X] Further documents are listed in the continuation of box C.

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° Special categories of cited documents :

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1

Date of the actual completion of the international search	Date of mailing of the international search report
26 March 1998	06/04/1998

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Beaudoin, O

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International Application No
PCT/US 97/23992

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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A	WO 95 15659 A (COMPRESSION LABS INC) 8 June 1995 see page 25, line 29 - page 29, line 14 ---	1,13
A	EP 0 708 564 A (AT & T CORP) 24 April 1996 see page 3, line 48 - page 4, line 27; figure 2 see page 8, line 44 - page 9, line 30; figure 5 ---	1,13
A	EP 0 685 968 A (VICTOR COMPANY OF JAPAN) 6 December 1995 see column 17, line 49 - column 19, line 8 ---	1,13
A	WO 96 27981 A (PHILIPS ELECTRONICS NV ;PHILIPS NORDEN AB (SE)) 12 September 1996 see page 2, line 13 - page 3, line 3; figure 1 see page 4, line 25 - page 5, line 12 ---	1,13
A	WO 97 39577 A (SNELL & WILCOX LTD ;KNEE MICHAEL JAMES (GB); SOMERVILLE STUART (GB)) 23 October 1997 see page 7, line 14 - line 27 ---	1,13
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Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Beaudoin, O

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